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DETERMINATION OF ^{210}Po CONTENT OF VIETNAMESE TOBACCO SAMPLES

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Abstract

Smoking is one of the leading causes of preventable death. In recent years numerous developed and less-developed countries initiated the prohibition of smoking in restaurants, workplaces, and public places. The Vietnamese government intends to follow the listed precautions. Over and above the number of some hazardous chemical components found in tobacco, ^{210}Po isotope content could enhance the probability of evolution of lung cancer. Recent study deals with determination of ^{210}Po activity concentration in 14 Vietnamese tobacco products (commercial cigarettes and pipe tobacco) by PIPS semiconductor alpha spectrometry. The obtained results clearly proved that the ^{210}Po activity concentration of the investigated samples varied between $7.40 \pm 1.09 - 128.64 \pm 11.22$ mBq/g. In case of the commercial cigarettes the average ^{210}Po content was 15.5 mBq/g whilst the average of the grown pipe tobacco was 20.4 mBq/g. To estimate the risk originated as a result of smoking the dose estimations were carried out.

Keywords: lung cancer, cigarette, pipe tobacco, smoking, polonium

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INTRODUCTION

In these days the crusade against smoking has great importance since the prevention of early death and inducing health problems such as lung cancer, pulmonary emphysema, cardiac diseases, stroke, etc. can be avoided via the tobacco control. In the basis of epidemiological surveys the number of death caused by smoking is higher than 6 million victims per year [1]. Between 1960 and 1970 several studies were published in connection with polonium content of inhaled and environmental cigarette smoke [2-5]. With developments in measurement techniques, especially the alpha spectrometry, further reports were released. Several scientists found clear-cut relations between the carcinomatous diseases and the polonium content in tobacco [4,6]. Cohen et al. [7] studied the effect of polonium on rats with inhalation of polonium enriched fume during 6 months. As a result of the experiment every each of them perished. In the course of dissection the highest polonium accumulation was appeared in the larynx and in the lower part of the lobes of the lung.

In Vietnam more than 40000 people die because of smoking and more than 44% of the male population are constant smokers [1]. The Vietnamese government takes steps to force back the smoking. In order to avoid the prospective smoking problems, a simulation model was evolved, which is composed by the following passages: Tax increases, clean air acts, mass communication campaigns, bans of tobacco advertising and youth smoking cessation programs [8]. Over and above the well-known chemical hazards originated from smoking, the informing facts about the risk caused by incorporated radionuclide content can make a deterrent impression on people. The aim of this study was to investigate the ^{210}Po content of several commercial and grown tobacco products from Vietnam and to compare the obtained results with other surveys.

MEASUREMENTS AND METHODS

Sample collection and preparation

The samples were collected in Vietnam. Altogether 21 commercial types and 7 grown types of cigarettes originated from trade were gathered in 2012. In addition, 2 types of the most popular pipe tobacco (*Nicotiana Rustica*) were also collected (Table 1.). The location of the collected samples can be seen in Figure 1.

Table 1.: ID of samples

Sample ID	City/province	Marks on the map	Sample ID	City/province	Marks on the map
Commercial tobacco			SC	Ho Chi Minh City	C
SP	Hanoi	A	YS	Ho Chi Minh City	C
WH	Nha Trang	B	C	Ho Chi Minh City	C
VG	Hanoi	A	CA	Ho Chi Minh City	C
TL	Hanoi	A	H	Ho Chi Minh City	C
V	Hanoi	A	Pipe tobacco		
MS	Hanoi	A	TM	Thanh Hoa province	II
V2	Hanoi	A	HP	Hai Phong city	I
WH	Hanoi	A	Grown tobacco		
MS	Can Tho	D	DN	Cao Bang province	1
BS	Hanoi	A	CM	Bac Kan province	2
TL2	Hanoi	A	VN	Thai Nguyen province	3
E	Nha Trang	B	HV	Lang Son province	4
WH2	Nha Trang	B	TB	Ninh Thuan province	5
Y	Nha Trang	B	IL	Gia Lai province	6
GL	Nha Trang	B	BC	Tay Ninh province	7
G	Ho Chi Minh City	C			

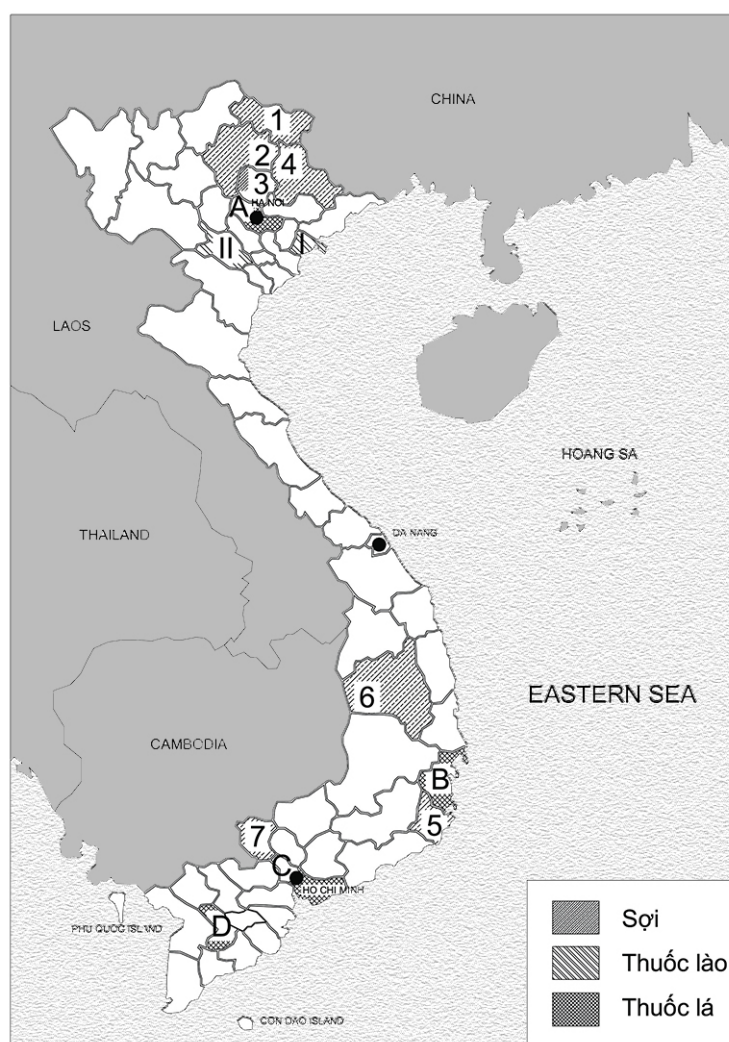


Figure 1.: Locality of the origin of the collected Vietnamese tobacco samples

The samples were dried at room temperature in order to avoid the sublimation of polonium isotopes [4]. Later, the samples were crushed with grinder to increase the efficiency of the chemical digestion. For the sample preparation, 2 g of air-dried tobacco were weighted and known amount of Po-209 tracer was added to each sample to determine the loss of polonium during chemical treatment. Classic digestion acidic leaching method was used with the following steps:

- 1st step – Adding 25 ml of HNO_3 to the sample and evaporating it to the volume of 4-5 ml. This step was repeated 3 times;

- 2nd step – Adding 25 ml of HCl (to eliminate the disturbing nitrate ions) and evaporating it to the volume of 4-5 ml. This step was repeated 3 times;
- 3rd step – Adding 25 ml of ultrapure water and evaporating it to the volume of 4-5 ml. This step was repeated 3 times;
- 4th step – Adding 0.5 ml of H₂O₂ to digest the organic compounds;
- 5th step – Preparation of 100 cm³ stock solution from the residue in volumetric flask with 0.5 M HCl.

Source preparation

Each sample source was prepared by spontaneous deposition for 3 h at 80 °C. 100 mg of ascorbic acid was added at the beginning of the deposition process to reduce Fe³⁺ ions. The deposition was carried out on a stainless steel plate with high nickel content (W.Nr. 1.4539, DIN 17 740, 25% Ni). The deposition efficiency was between 85 and 90%. The prepared sample sources were measured with ORTEC Soloist PIPS type semiconductor detector system for a 80000s period.

The Minimal Detectable Activity (MDA) were calculated by the classic Currie formulae [9].

$$MDA = \frac{2.71 + 4.65 \cdot \sqrt{I_h}}{\eta}$$

Where:

MDA: Minimal Detectable Activity (Bq)

I_h: Background counts

η: Efficiency of the detector

In case of the measurement different 4 detectors were used and their MDA's ranged between 0.30-1.41 mBq.

The peak at 4866 keV of the artificial Po-209 tracer and the peak at 5305 keV of the ²¹⁰Po isotope were used to evaluate the sample sources [10].

Dose estimation

In the past years the dose conversion factors and the recommended value related to the amount of inhaled ²¹⁰Po had been changed. This is the reason why comparing of newly obtained doses with the results of previous international surveys run into difficulties. The determination and validation process of dose conversion factors is a fairly complex job [11]. The recommended dose conversion factor related to ²¹⁰Po was 4.3×10⁻⁶ Sv/Bq in UNSCEAR

1993 report. However, the following (UNSCEAR 2008) report suggested the value of 3.3×10^{-6} Sv/Bq, which is less strict than the previous recommendation.

The dose conversion factor in case of UNSCEAR 2008 is 3.3×10^{-6} Sv/Bq lower than the UNSCEAR 1993 recommended 4.3×10^{-6} Sv/Bq. The new dose conversion factor is presumably based on upgraded epidemiological surveys. In case of the previous dose conversion factor the estimated dose is 30% higher than the recent one's. This is the reason why if the old dose conversion factor is used for dose estimation the result will be overestimated.

On the other hand, the amount of inhaled ^{210}Po aroused a debate among scientists in the recent years. It has been found by Papastefanou et al. [12] that only 70% of the total amount of ^{210}Po gets into the smoke from the tobacco and only 20% inhaled during smoking. Skwarzec et al. [13] published 50% while Carvalho and Oliveira [14] have taken into account 5-37% for inhalation rate. It could be explained with impartial reasons, such as the efficiency of the applied filters or the different protocols used during their investigations. In order to compare the results of dose assessment with our previous surveys [15], in present study, the rate of inhaled ^{210}Po was 20%, the dose conversion factor was 3.3×10^{-6} Sv/Bq, and the number of the daily smoking was 20 cigarettes per day.

The annual committed effective dose contribution originated from smoking was calculated with the following formula:

$$E = F_I \times K \times G \times C \times t$$

Where:

E : the committed effective dose from inhalation (Sv)

F_I : the average transfer factor from the tobacco to inhaled part (0.2)

K : the inhalation dose conversion factor of ^{210}Po (3.3×10^{-6} Sv/Bq)

G : the number of cigarettes smoked (20 cigarettes/day)

C : the concentration of ^{210}Po in 1 cigarette (Bq/cigarette)

t : the duration of smoking (365 days)

The average weight of the investigated cigarettes was 0.7 g. This value was used in case of the pipe tobacco and the grown samples in order to compare the theoretical dose contribution if those samples will be used in cigarette production.

RESULTS AND DISCUSSION

Activity concentration of ^{210}Po in tobacco samples

The average values of the investigated samples are illustrated in Figure 2. In case of the commercial cigarette samples (SP, WH, VG, ..., CA, H) the ^{210}Po activity concentration is in the range between 12.98 ± 1.88 to 41.23 ± 4.35 , with average value of 21.79 ± 2.76 mBq/g. The results for pipe tobacco samples were 128.64 ± 11.22 (TM) and 33.73 ± 3.75 mBq/g (HP), which are several times higher than in case of cigarettes. The ^{210}Po contents of the grown tobacco samples (DN, CM, ..., IL, BC) varied between 7.40 ± 1.09 to 61.33 ± 4.79 Bq/g with average value of 29.17 ± 2.77 Bq/g.

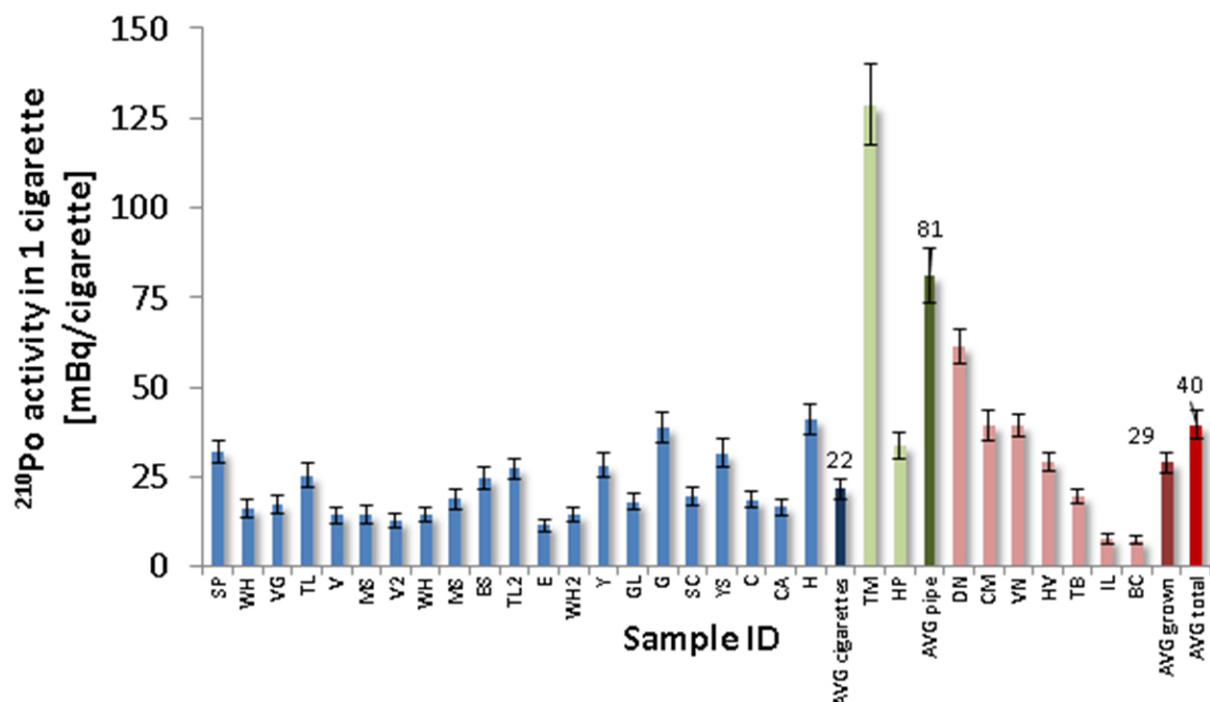


Figure 2.: ^{210}Po activity concentration of the investigated Vietnamese tobacco samples

The obtained results clearly prove that ^{210}Po activity concentration was the highest in case of the pipe tobacco. The increment could be explained by the intensive utilization of phosphate fertilizers that have elevated Ra-226 concentration, quite often of 50 times higher than the Ra-226 content in soils [16].

Several previous surveys dealt with the determination of the ^{210}Po isotope in tobacco samples. In Figure 3, the average values for tobacco samples originated from 16 different countries can be seen.

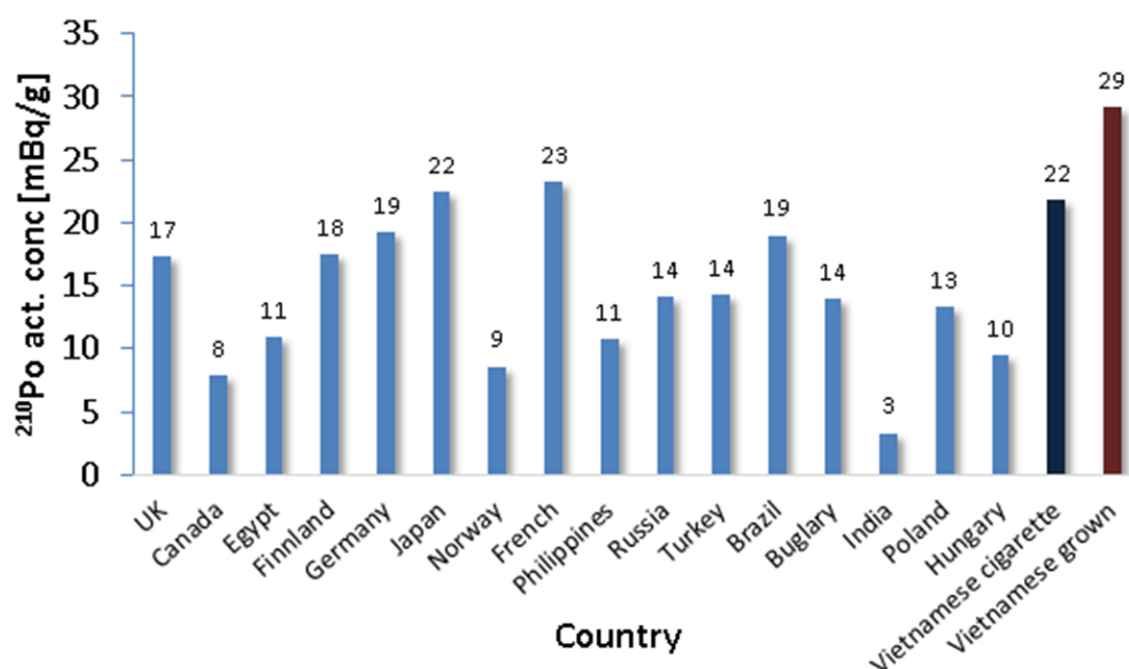


Figure 3.: Average ^{210}Po activity concentration of cigarettes previously surveyed on foreign samples [13-21]

The obtained results for the commercial Vietnamese cigarettes fit into the results found in other countries. However the ^{210}Po activity concentration in Vietnamese tobacco samples does not exceed significantly the measured values of other countries the obtained results more than 7 times higher than the Indian tobaccos. That fact can be occurred as a result of different

soil or fallout conditions, since the accumulated ^{210}Po content greatly depends on the radionuclide content of the cultivated area furthermore the amount of the ^{222}Rn daughters in case of outdoor air. The applied Phosphate fertilizers can enhance the ^{210}Po activity concentration of the tobacco plants depending on the ^{226}Ra (^{210}Po) content of the starting materials. The pipe tobacco with 128.64 ± 11.22 (TM) mBq/g ^{210}Po activity concentration is prominently higher than the other values, which should be investigated to find the reason of ^{210}Po increment.

Estimated dose caused by Vietnamese tobaccos

The annual committed effective dose contributions originated from smoking were calculated with the above mentioned parameters and the obtained result are illustrated in Figure 4.

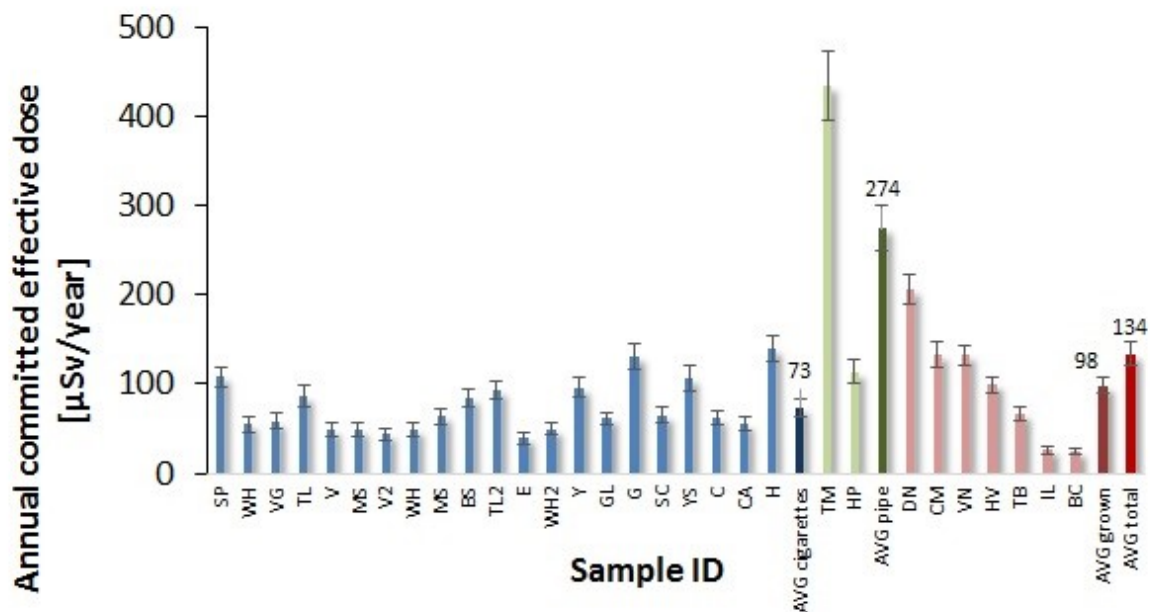


Figure 4.: Annual committed effective dose contribution of the investigated Vietnamese tobacco samples

The diagram shows that the dose contribution ranges between 39.19 ± 6.04 to 139.05 ± 14.67 μSv/a in case of commercial cigarettes with average value of 73.49 ± 9.31 μSv/a. The

grown samples are in possession of more or less the same ^{210}Po content. The values varied between 24.96 ± 3.68 to 206.84 ± 16.76 $\mu\text{Sv/a}$ with average value of 98.37 ± 9.34 $\mu\text{Sv/a}$. The pipe tobacco samples could cause the highest danger because of their elevated ^{210}Po content. The calculated dose contribution values were 113.76 ± 12.65 $\mu\text{Sv/a}$ and 433.85 ± 37.84 $\mu\text{Sv/a}$, which are approximately 1 magnitude higher than the average of the commercial cigarettes. On the basis of the obtained results, it can be clearly stated that only the TM labelled pipe tobacco samples contains high ^{210}Po content. The other surveyed sample do not contain significantly high ^{210}Po content compared with several ^{210}Po survey.

CONCLUSION

To sum it up the investigated Vietnamese tobacco samples do not spell elevated danger in radiological point of view compared with cigarettes traded in other countries. Nevertheless, in case of certain factors (e.g. fall-out of Radon progenies, high ^{226}Ra content in soil, etc.) elevated ^{210}Po content can occur in tobacco plant. The determination of transfer mechanisms between the tobacco plant and the environmental parameters is recommended to prevent the accumulation of ^{210}Po in commercial tobaccos.

The average value of the commercial cigarettes can cause ~ 74 $\mu\text{Sv/a}$ committed effective dose contribution for smokers. To exemplify the risk of smoking the received dose is commensurable with certain in case of X-ray diagnostic procedures. For example the posteroanterior study of chest causes 20 μSv effective dose, in case of skull X-ray the received effective dose is 100 μSv [22]. On the basis of these facts it can be stated that the smoking can cause as high dose as some medical diagnostic procedure, which destined for protect health. That dose surplus can increase the risk of evolution of lung cancer beside the effects of other harmful compounds can be found in tobacco. That risk increment is avoidable with reduce of smoking.

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